Petrographic Characterization of Deformation Mechanisms and Kinematics in Post-Cleavage Faults Accommodating Differential Uplift of the Hsuehshan Range: Taiwan

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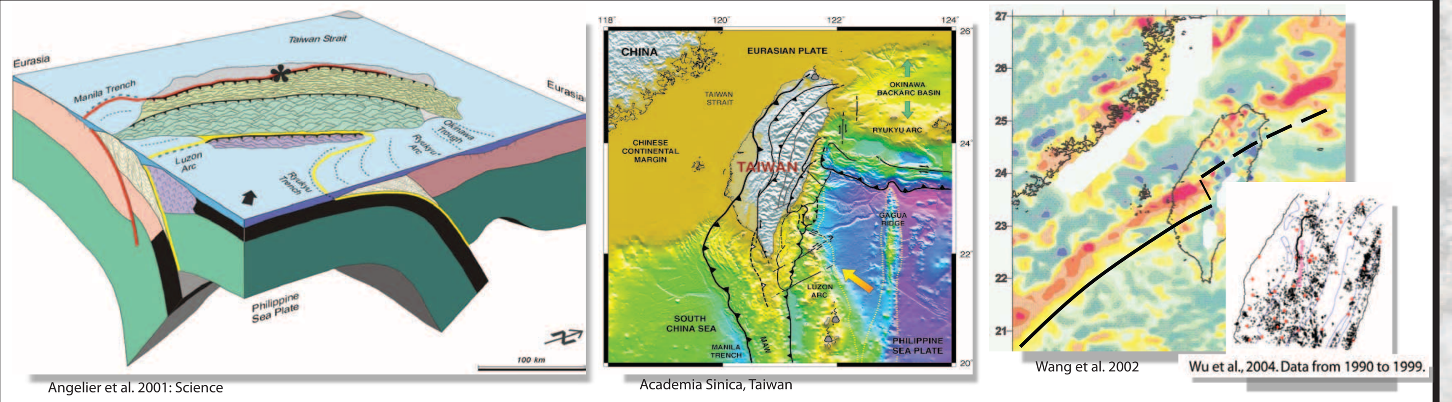
Abstract

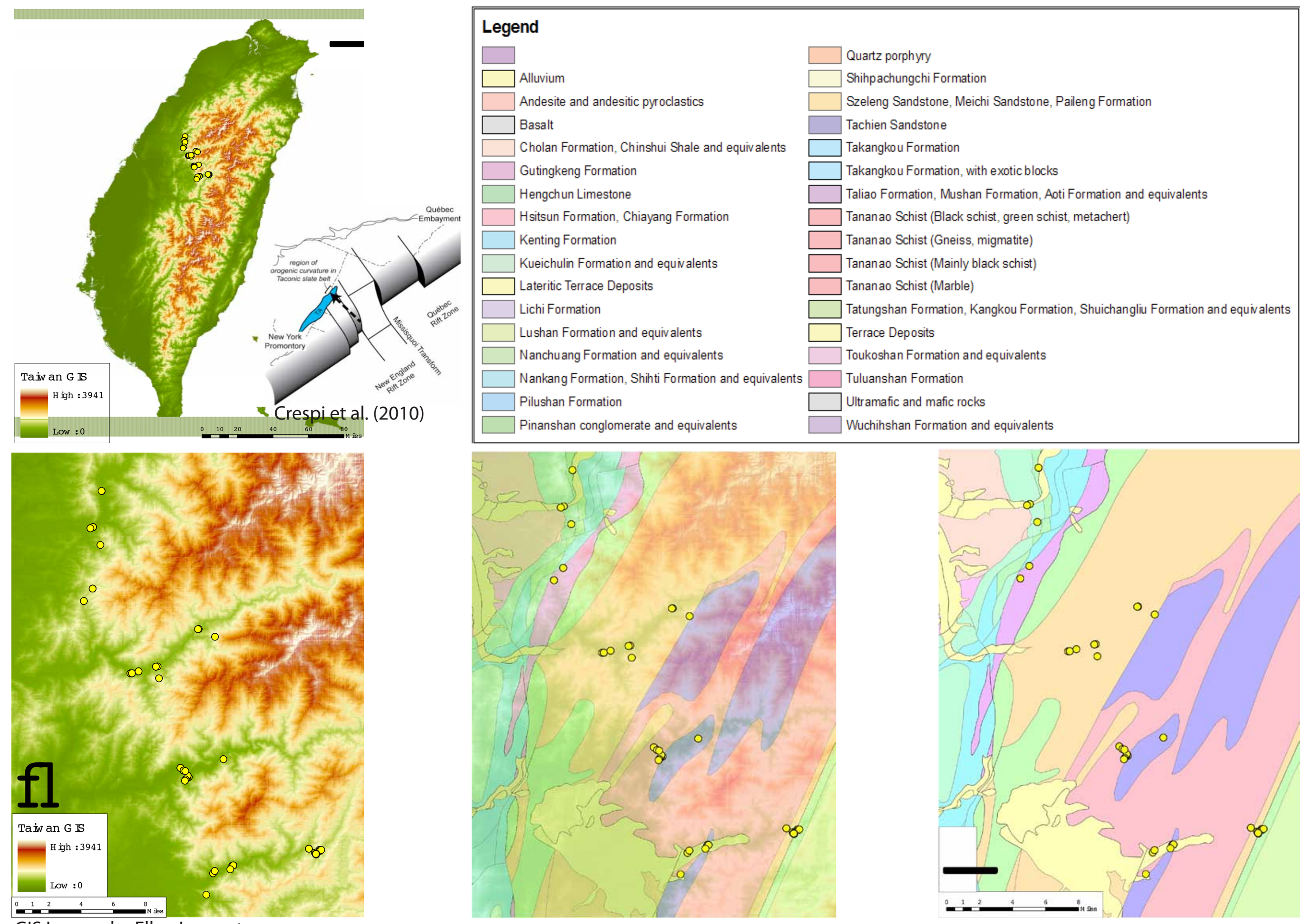
Much remains unknown about how continental margin architecture, built from a prior tectonic rifting event, can affect past and ongoing collisional orogenisis. West-central Taiwan can help us to understand the fundamentals of this problem because it is thought to be the site of a relic passive margin fracture zone that is controlling the contemporary uplift patterns of the Hsuehshan Range. We focus on microstructures within an oriented sample to identify the primary deformation mechanisms and kinematics. We found an abundance of clasts showing cataclasis while observing the deformation at grain scale. We found that our observations of the asymmetric microstructures are also consistent with the kinematics of the system observed in the field.

The focal point of our study is a single fault within a suite of recently recognized northwest-striking faults cutting Pliocene-Miocene sandstone sequences just southwest of the Hsuehshan Range. The sampled fault material consists of fault rock and cohesive fault rock taken from a meter-scale thick fault zone east of the Anmashan Anticline near Kukuan Taiwan. Thin sections were made normal to the fault plane and both parallel and perpendicular to the slip direction.

The bulk of the faults are north-northeast dipping oblique thrust faults and strain inversions suggests the maximum shortening direction to be southwest and northeast. These post-cleavage faults are north-northwest trending nearly normal to a northeast trending regional magnetic high that is believed to mark the edge of full-thickness continental crust northwest of the high. This offset nearly conforms with the topographic break that separates the higher Hsuehshan Range to the northeast from the lowlands of the Puli Basin to the southwest. We infer it to be the northeast facing margin of what appears to be a promontory in the lower plate pointing to the east. This promontory of continental crust in the footwall is now acting as a deformation guide as the trench-fill sediments making up the orogen move northwest in response to collision with the Luzon arc.

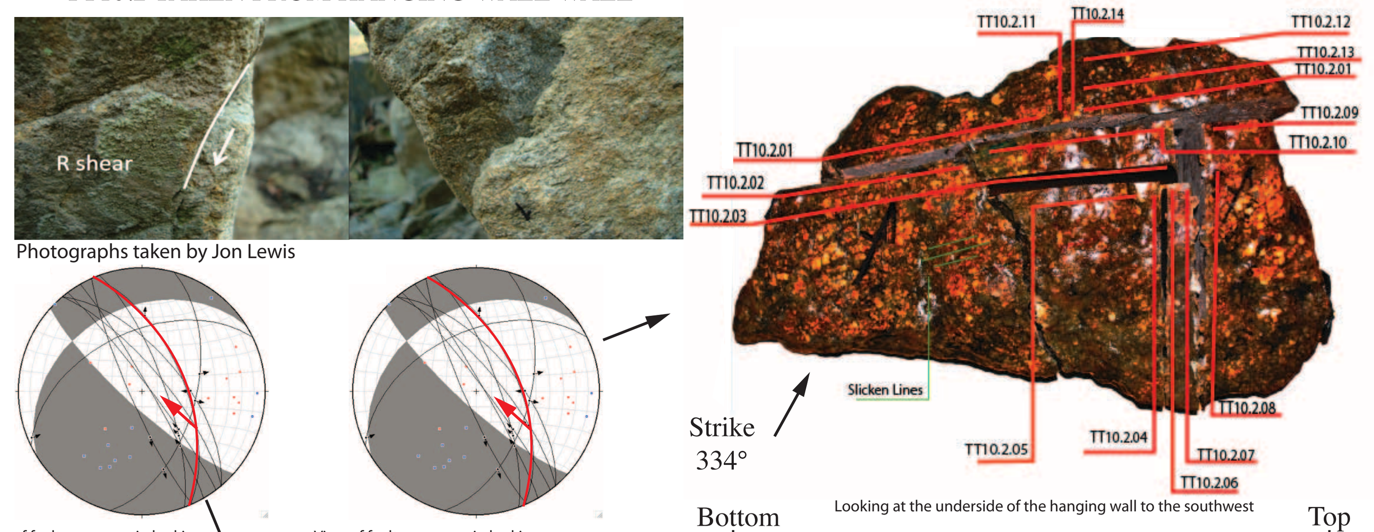


Angelier et al. 2001. Science — Academia Sinica, Taiwan — Wang et al. 2002 — Wu et al., 2004. Data from 1990 to 1999.



Crespi et al. (2010)
GIS Images by Ellen Lamont

TT10.2 TAKEN FROM HANGING WALL WALL



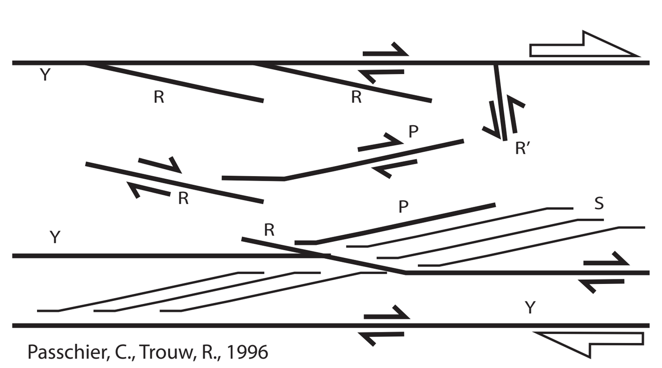
Photographs taken by Jon Lewis

View of fault zone margin looking along strike toward the southeast

View of fault zone margin looking perpendicular to the fault plane toward the southeast

A) A cataclastic quartz fabric interpreted to be cut and broken by pseudotachylyte. (sense of shear: top to the right)
B) Abundance of calcite indicating the opening direction of veins interpreted to be text book stacking. (sense of shear: top to the right)
C) A cataclastic quartz fabric interpreted to be cut and broken by pseudotachylyte. (sense of shear: top to the right)
D) Abundance of calcite indicating the opening direction of veins interpreted to be text book stacking. (sense of shear: top to the right)
E) Quartz grain interpreted to be conjugate with R-shearing and P-shearing revealing the ideal slip directions. The distinct line to the right of the grain is interpreted to be a R' shear. (sense of shear: top to the right)
F) A cataclastic quartz fabric interpreted to be cut and broken by pseudotachylyte. Appears to be an injection vein after fracturing occurred. (sense of shear: top to the right)

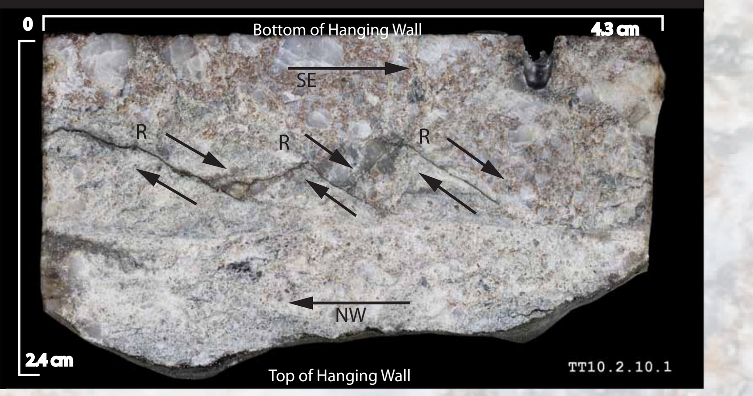
KINEMATICS KEY



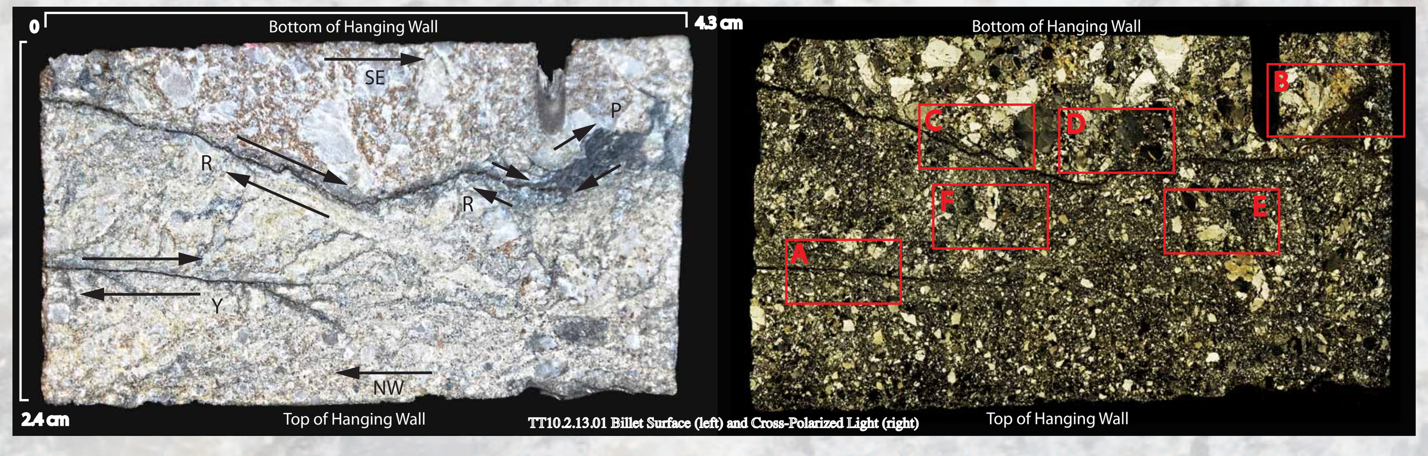
Passchier, C., Trouw, R., 1996

KINEMATICS

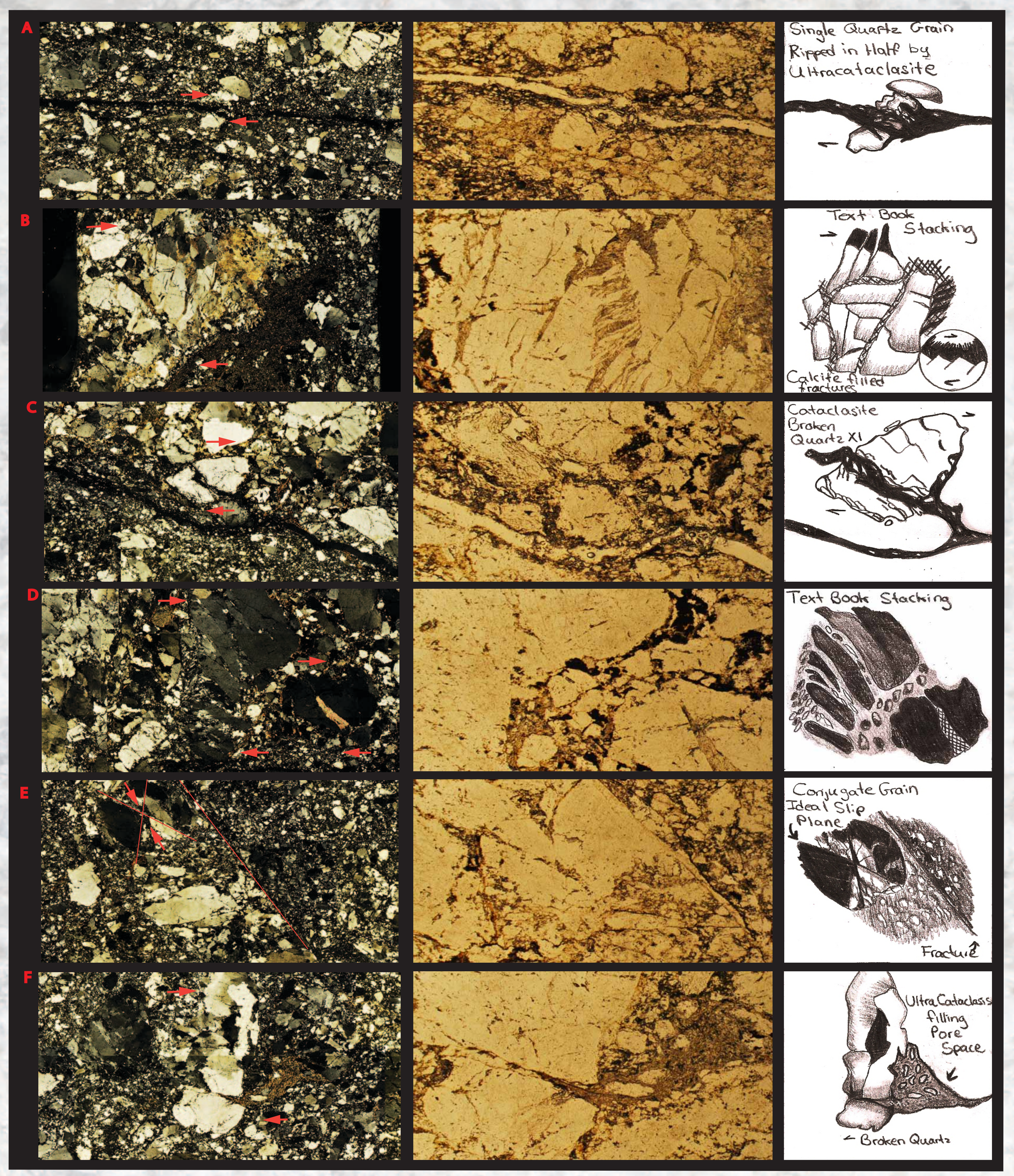
Parallel to Slickenlines (Looking Southeast)



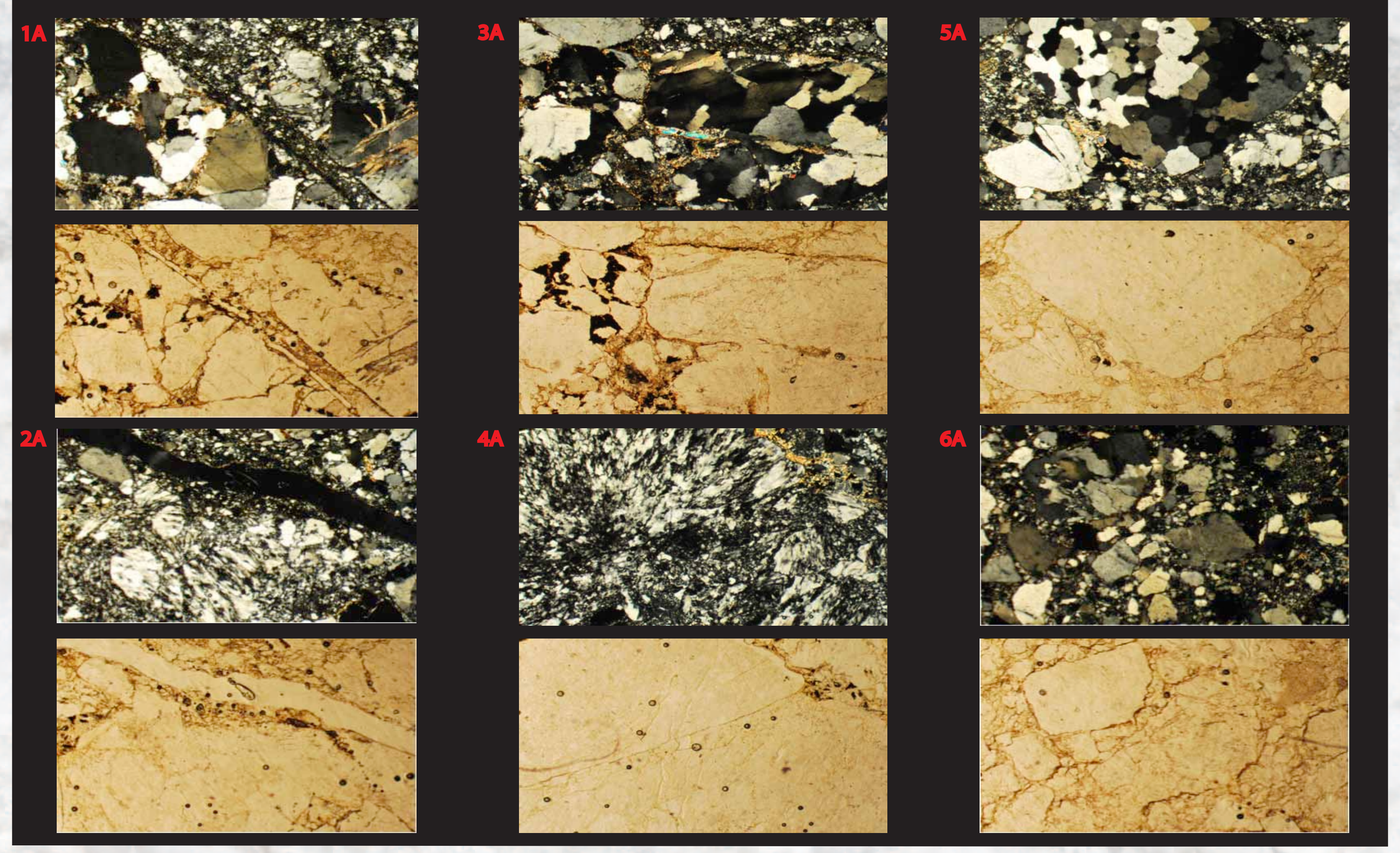
Perpendicular to Slickenlines (Looking Southwest)

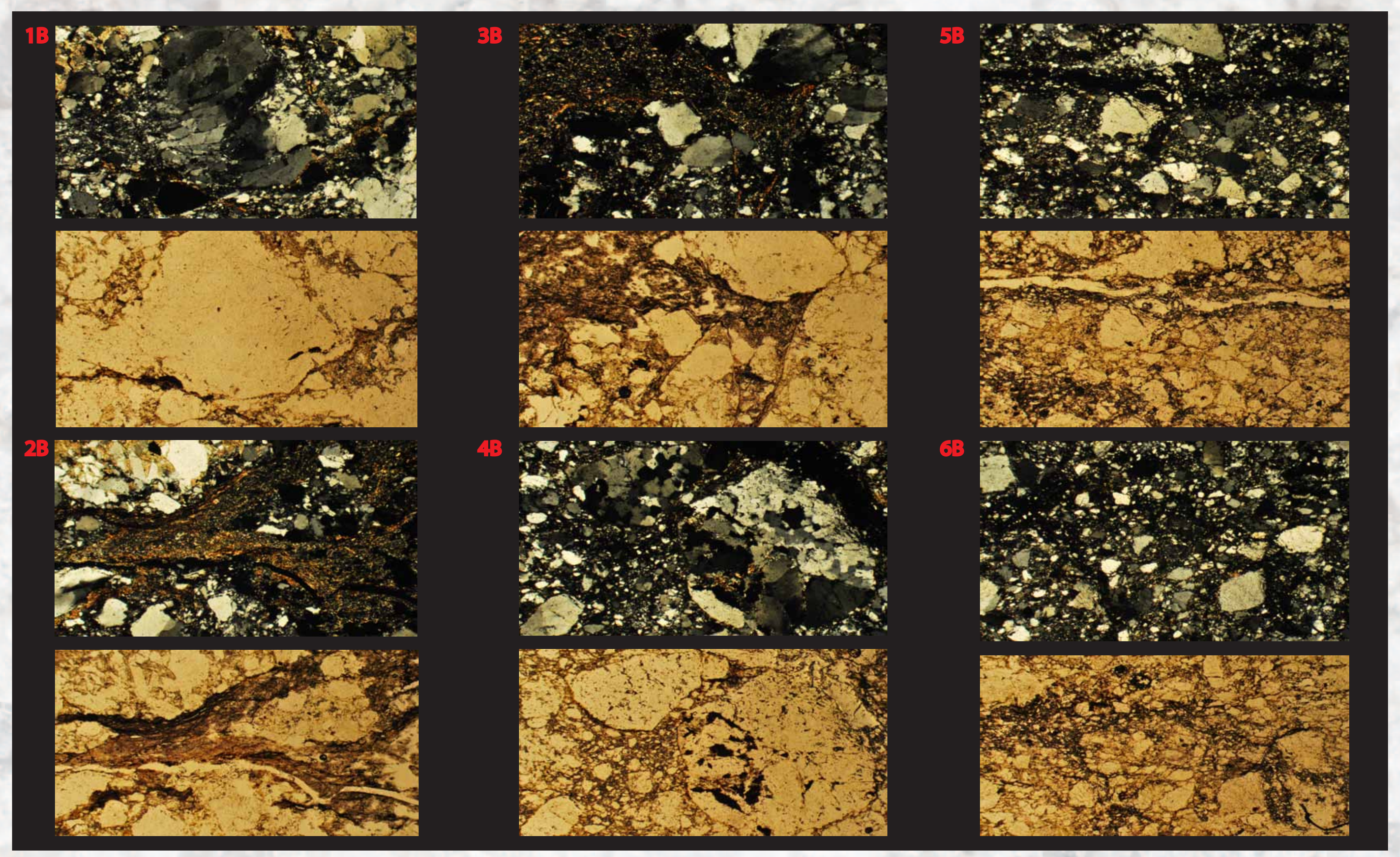


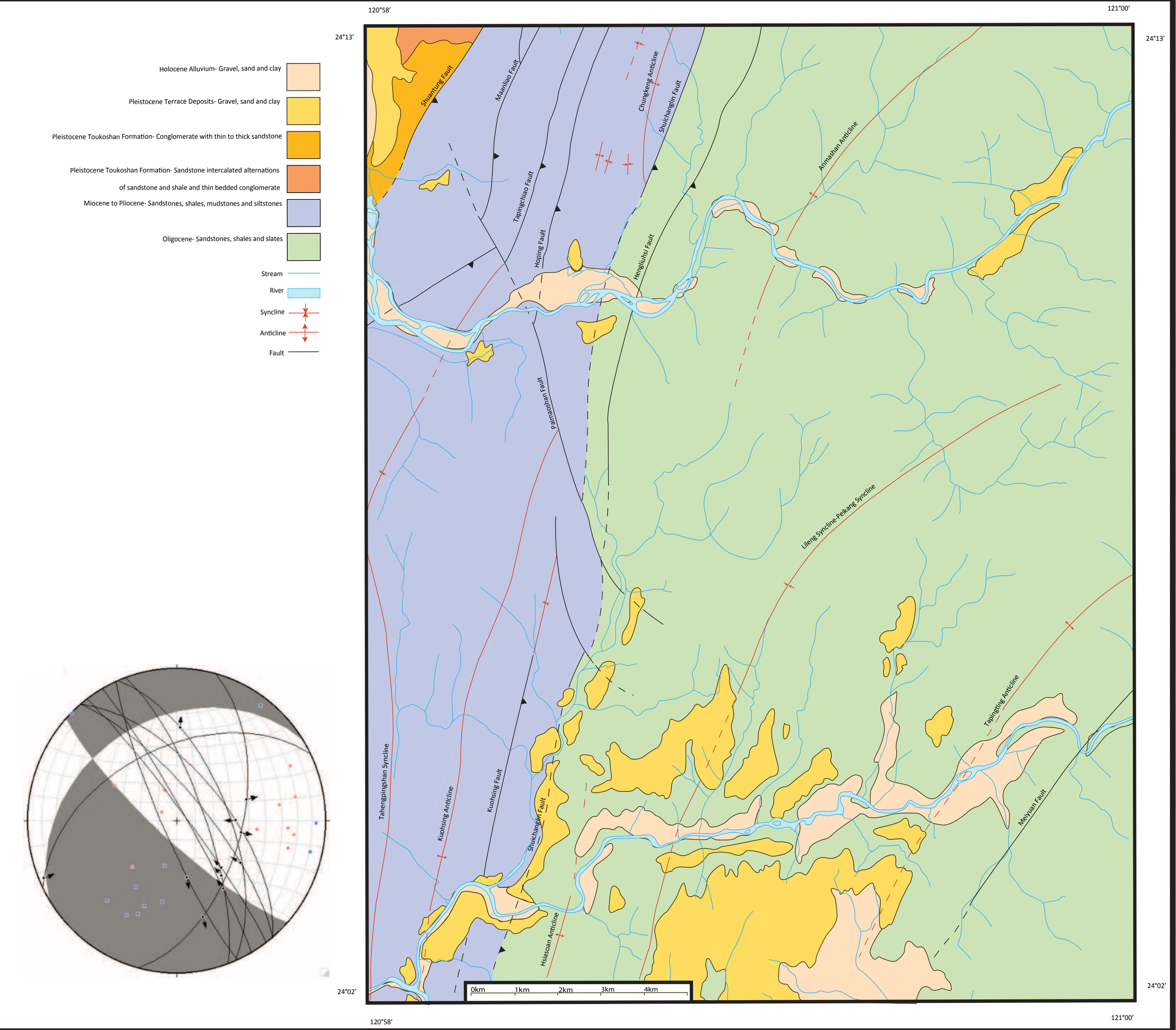
Perpendicular to Slickenlines (Looking Southwest) — Perpendicular to Slickenlines (Looking Southwest)



DEFORMATION MECHANISMS

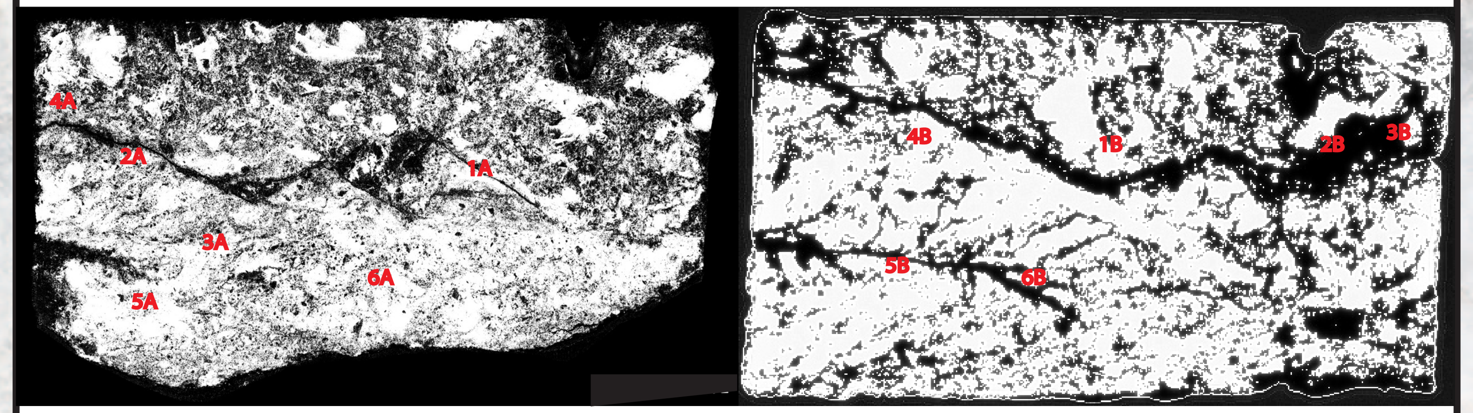






DEFORMATION MECHANISMS KEY (Evidence for near-surface cohesive brittle fault rocks with cohesive cataclasite and pseudotachylyte)

A TT10.2.10.01 — B TT10.2.13.01



1A) Interpreted to be pseudotachylyte in which the generation surface has been reactivated because of the abundance of inclusions. (Deformation mecahanism: cataclasis)
2A) Interpreted to be pseudotachylyte along generation surface containing some very small inclusions from the surrounding fault rock. The contact is sharp and separates the shear zone from the fault rock. (Deformation mechanism: ultra-cataclasis)
3A) Strong undulose extiction within quartz crystal parallel to the developing slip plane located between 5A and 3A. (Deformation mechanism: dislocation creep)
4A) Chalcedony crystal showing an interpreted cataclastic fabric close to the generation surface. (Deformation mechanism: cataclasis)
5A) Dynamically recrystallized quartz grain in a less recent active region of the shear zone with polygonal aggregates. (Deformation mechanism: dynamic recrystallization)
6A) Dynamically recrystallized quartz grain in a less recent active region of the shear zone with interlobate aggregates. (Deformation mechanism: dynamic recrystallization)

1B) Cataclastic quartz fabric near reactivated zone with calcite and smaller subgrains infilling the fractures across the entire section and interpreted to have been fractured in-situ. (Deformation mechanism: cataclasis)
2B) Injection of pseudotachylyte with calcite filling in a large area of pore space within the reactivated generation zone. (Deformation mechanism: ultra-cataclasis)
3B) Injection of pseudotachylyte with calcite filling in the boundaries around grains with less pore space. (Deformation mechanism: ultra-cataclasis)
4B) Dynamically recrystallized quartz grain near generation zone that has not been reactivated, further indicating that the zone of interest has remained inactive for a prolongued period of time. (Deformation mechanism: dynamic recrystallization)
5B) Interpreted to be the youngest generation zone cutting a quartz grain in half leaving a young cataclastic fabric. (Deformation mechanism: cataclasis)
6B) Tail end of the youngest generation zone revealing pseudotachylyte infiltrating available pore space. (Deformation mechanism: cataclasis)

RESULTS AND DISCUSSION

The big picture of this research is designated to building a stable case to reveal the existence of a promontory at depth that is a key factor in driving collisional orogenisis in Taiwan. The promontory can easily be identified or interpreted to exist from topographic relief maps and maps showing magnetic anomaly data. It is enough data to say that something exists at depth, but to say that it is controlling contemporary uplift in the Hseushan range, it is necessary to look at all the evidence with as many different perspectives as possible. This being said, it is my job to examine cohesive brittle fault rock taken from the eastern edge of the promontory to see if; one, faults do exist with the correct orientation (northewest striking) and two, that the faults along this promontory are late-stage and near the surface (brittle). We want to identify the faults as late-stage because it identifies the promontory as being a contributing crustal feature existing today in affecting collisional orogenisis. While examining the micro-structures we find that the kinematics correlate with the kinematics of the regional zone of interest. They all show evidence of reactivated oblique thrusting to the northwest along faults striking to the northwest. We wanted to get a closer look at the micro-structural deformation mechanisms and identify them as brittle. If the grain mass in thin section revealed signs of cataclasis or ultra-cataclasis in-situ, we can interpret the fault rock at grain scale to reflect what the faults are doing on a regional scale. If the faults are indeed brittle, they have responded to low temperature, high pressure situations interpreted as late-stage. While examining the fault rock at grain scale we see what we interpret to be ultra-cataclasis as seen in the deformation mechanisms section. We see cataclastic fabric in quartz grains that are cross-cut regularly throughout the grain mass suggesting that each grain responded to stress in-situ. We interpret the faults to be late stage responding directly to the promontory observed at depth believed to be the edge of full-thickness continental crust from a prior rifting event.

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I would like to thank the National Science Foundation for award #0738953 as well as the principle investigator and my advisor, Jon C. Lewis from Indiana University of Pennsylvania for the opportunity and assistance. My research would not be made possible without the help of the Geoscience Department and faculty at IUP. I would like to thank Y-C Chan and J-C Lee of Academia Sinica for their help and for providing a vehicle for our field work. Thank you to Rick Allmendinger for providing the shareware StereoNet. I would also like to thank Tony Gutierrez and Graham Snodgrass from the U.S. Army institue of public health for the high resolution images of TT10.2.07.01 and TT10.2.10.01 made available by use of the Macropod.